CERTS

CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

Supplier and Control Area Performance Monitoring System©

CALIFORNIA ENERGY COMMISSION

CONSULTANT REPORT

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The technical leadership for the development of the CERTS Supplier's and Control Area Performance for AGC and Frequency Response Real-Time Monitoring System was provided by Carlos Martinez, Electric Power Group.

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Abstract

The Consortium for Electric Reliability Technology Solutions (CERTS) has been working with NERC, Regional Transmission Organizations, Independent System Operators, and other electric industry organizations to research, develop, and disseminate new methods, tools and technologies to protect and enhance the reliability of the U.S. electric power system under the emerging competitive electricity market structures. The monitoring system offers a base from which grid security and market efficiency can be improved to help protect the market from "gaming" and other forms of market manipulations. CERTS has developed the Grid Real-Time Performance Monitoring and Prediction Platform (Grid-3P) to manage grid reliability and monitor market performance in real time. The purpose of the Supplier and Control Area Performance Monitoring System is to provide real-time intelligence on grid operations that will enable operators to monitor performance of Suppliers to provide competitive services and respond to their performance in a predictable manner.

Preface

The U.S. Electricity Grid Today The U.S. electric power system is in the midst of a fundamental transition from a centrally planned and utility-controlled structure to one that will depend on competitive market forces for investment, operations, and reliability management. Electricity system operators are being challenged to maintain the reliability of the grid and support economic transfers of power as the industry's structure changes and market rules evolve. Meanwhile, U.S. economy depends more than ever on reliable and high quality electricity supplies. New technologies are needed to prevent major outages such as those experienced on the Western grid on August 10, 1996, which left 12 million people without electricity for up to eight hours and cost an estimated $2 billion.

The Consortium for Electric Reliability Technology Solutions (CERTS) was formed in 1999 to research, develop, and disseminate new methods, tools, and technologies to protect and enhance the reliability of the U.S. electric power system and functioning of a competitive electricity market. CERTS is currently conducting research for the U.S. Department of Energy (DOE) Transmission Reliability Program and for the California Energy Commission (CEC) Public Interest Energy Research (PIER) Program. The members of CERTS include the Electric Power Group, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, the National Science Foundation's Power Systems Engineering Research Center, and Sandia National Laboratories.

SUMMARY REPORT – WORK IN PROGRESS

SUPPLIER AND CONTROL AREA PERFORMANCE MONITORING SYSTEM©

UTILIZATION OF Grid-3P FOR AUTOMATIC GENERATION CONTROL (AGC), FREQUENCY RESPONSE RESERVES (FRR) AND ANCILLARY SERVICES (AS) REGULATION

February 28, 2003

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FOREWORD

The Consortium for Electric Reliability Technology Solutions (CERTS) has been working on research and development of tools and technologies for management of grid reliability. The Supplier and Control Area Performance Monitoring System© was developed by the Electric Power Group (EPG). The development team was led by Carlos Martinez of the Electric Power Group. The Supplier and Control Area Performance Monitoring System is one of the applications developed by EPG as part of a suite of applications using the Grid Real-Time **P**erformance Monitoring and **P**rediction **P**latform (Grid-3P©) to provide the capability to monitor grid reliability and market performance in real time. The Grid-3P can be used by Regional transmission Organizations (RTO's), Independent System Operators (ISO's), NERC Reliability Authorities, transmission companies, control areas, and utilities to monitor voltage, to provide VAR control, and for other applications to monitor grid reliability.

This summary documents the work effort to date for development of the Supplier and Control Area Performance Monitoring System and describes the applications and functions of the software. The target users for this application are the RTO/ISO system dispatchers and operating engineers. The Supplier and Control Area Performance Monitoring System uses the Grid 3-P platform for the monitoring, tracking and prediction of Supplier's response to Automatic Generation Control (AGC), Frequency Response Reserves (FRR) and Ancillary Services (AS) Regulation requirements. The application allows tracking and prediction for both the control area and supplier or generator performance for the above services. Completion of the full software program is scheduled for Second Quarter, 2003.

This CERTS project was funded by the Department of Energy, Office of Power Technologies, Transmission Research Program, Phil Overholt, Program Manager, and the California Energy Commission's Public Interest Energy Research (PIER) program. CERTS research program is managed by Lawrence Berkeley National Lab, Joe Eto, Program Manager.

This application is currently in the final phase of development prior to beta testing by CAISO. EPG, prior to deployment, will have prepared a User's Guide, a Training Manual, and associated documentation to describe the application. For more information contact Joseph Eto at LBNL or Carlos Martinez at EPG. This report is prepared as part of Ernest Orlando Lawrence Berkeley National Laboratory Subcontracts 6496360 and 6508899 under Contract DE-AC03-76SF00098 with the U.S. Department of Energy.

The Supplier and Control Area Performance Monitoring System is part of the suite of applications being developed for the Grid-3P platform to provide the capability to

monitor grid and market performance in real time and manage grid reliability. This suite of tools include:

1. Area Control Area (ACE)–Frequency Monitoring System
2. Area Interchange Error (AIE) Monitoring System
3. Real-Time Voltage Monitoring and VAR Management System
4. Phasor Monitoring Applications for Dispatchers and Operating Engineers

INTRODUCTION

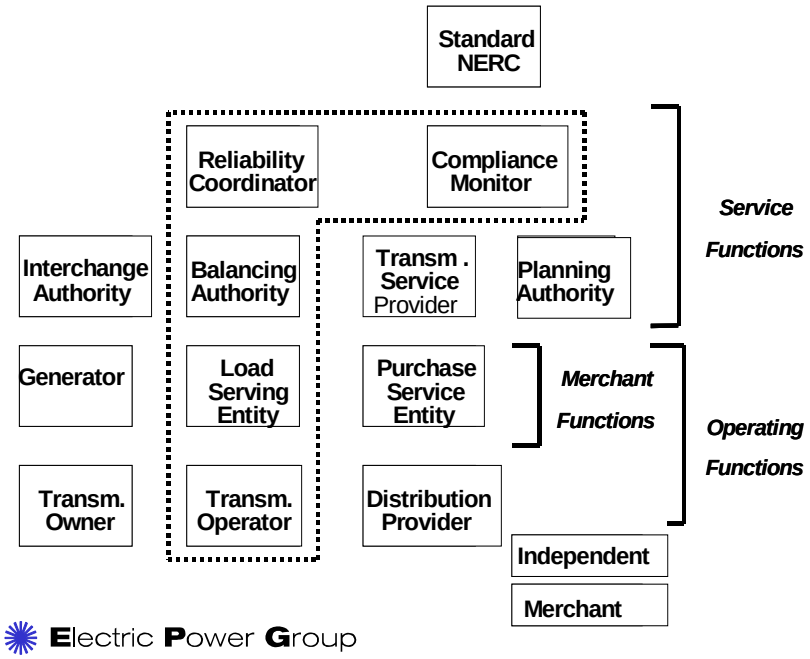
The Consortium for Electric Reliability Technology Solutions (CERTS) has been working with NERC, Regional Transmission Organizations, Independent System Operators, and other electric industry organizations to research, develop, and disseminate new methods, tools and technologies to protect and enhance the reliability of the U.S. electric power system under the emerging competitive electricity market structures. The monitoring system offers a base from which grid security and market efficiency can be improved to help protect the market from "gaming" and other forms of market manipulations.

In particular, CERTS has developed the Grid Real-Time **P**erformance Monitoring and **P**rediction **P**latform (Grid-3P) to manage grid reliability and monitor market performance in real time. Grid-3P complements and integrates with existing SCADA systems and utilizes real time data engines and graphic-geographic visualization tools to develop reliability applications to assist operating authorities, e.g., Independent System Operators (ISO's), Regional Transmission Organizations (RTO's), Reliability Coordinators and Control Area Dispatchers in their management of grid reliability. This summary report describes the application of the Grid-3P Platform for the real time monitoring, tracking and prediction of CAISO Control Area and Supplier Performance Monitoring of AGC, FRR and Regulation AS.

CERTS has been developing real-time grid tools for the different entities outlined in NERC's Reliability Functional Model shown in Figure 1 below. Technologies being developed by CERTS focus first on the applications required by the stakeholders within the dotted line. These functions include reliability coordination, compliance, balancing, procurement, and actual usage of the services by the Transmission Operators.

The purpose of the Supplier and Control Area Performance Monitoring System is to provide real-time intelligence on grid operations that will enable operators to monitor performance of Suppliers to provide competitive services and respond to their performance in a predictable manner.

Figure 1: NERC Reliability Functional Model



Value Proposition for Users

The Supplier and Control Area Performance Monitoring System was developed for use by CAISO real-time operators, operating engineering staff and management. The value of the application for the users is as follows:

Real-time Operators:

- Enhanced ability to monitor and track the CAISO Control Area and Supplier response to AGC, including the ability to segregate into sub-regions (i.e., North and South California).
- Monitor Control Area and Supplier actions, their performance and near real time predictions to FRR.
- Identify required changes in Next Hour's scheduled Ancillary Services for Regulation.
- Identify required changes in Next Day's scheduled Ancillary Services for Regulation.

Operating Engineers:

- Provides the operating engineer with unit specific performance information.
- Provides the operating engineer with information to work with plant owners to improve their response to AGC, FRR and Ancillary Services Regulation.

Management:

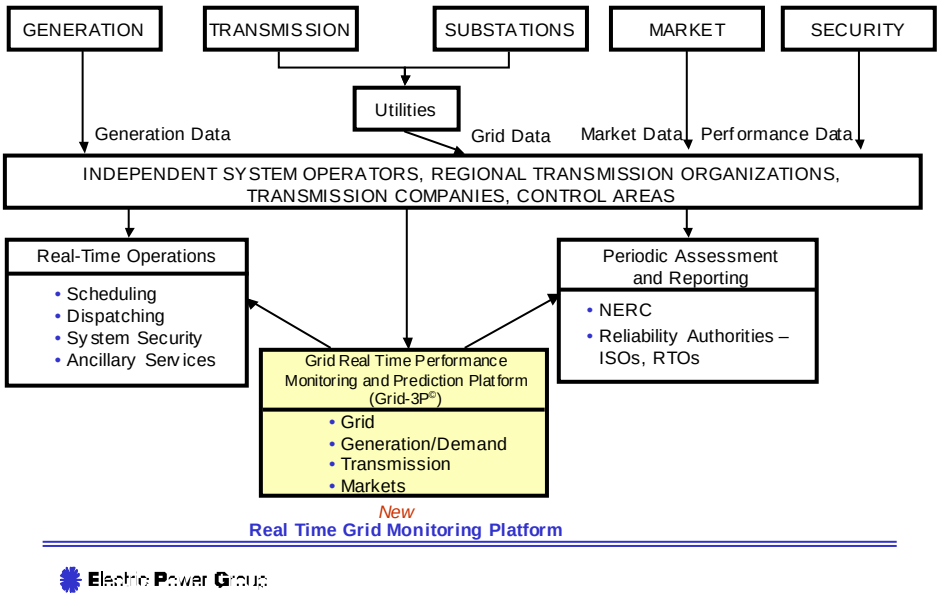
- Provides near real time operational information that allows them to evaluate the effectiveness of market rules and tariffs.

CONTROL AREA AND SUPPLIER PERFORMANCE OVERVIEW

Development of the Grid Performance Monitoring and Prediction Platform (Grid-3P) for Performance Monitoring

The vertically integrated business model historically used by utilities has evolved to a segmented market with functions dispersed among different entities. Figure 2 shows the business functions segmented into generation, transmission, distribution, markets and security. The Grid Real-Time Performance Monitoring and Prediction Platform (Grid-3P) has been developed by CERTS to serve as a common platform for the development of reliability applications for real-time monitoring and prediction for the reliability performance of control areas, generation, grid, markets and security. Control area's ACE, interconnection's frequency and interchange data using the Grid-3P provides a common tool to be utilized by NERC Reliability Coordinators, Control Area Dispatchers, and Transmission Dispatchers. Control Area Dispatchers, and Transmission Dispatchers. The bottom of Figure 2 also shows that reliability applications developed using Grid-3P serve as complement to traditional SCADA/EMS systems and for the periodic reporting requested by NERC for performance assessment in real time and post disturbances.

Figure 2: Grid-3P for Real Time Grid Monitoring



Grid-3P for System Performance

Figure 3 below, within the shaded area, identifies the areas of this application and highlights the functionality related to tracking, monitoring, and predicting the Supplier and Control Area Performance relating to AGC, FRR, and Regulation AS.

Figure 3: Operational and Reliability Management Responsibilities

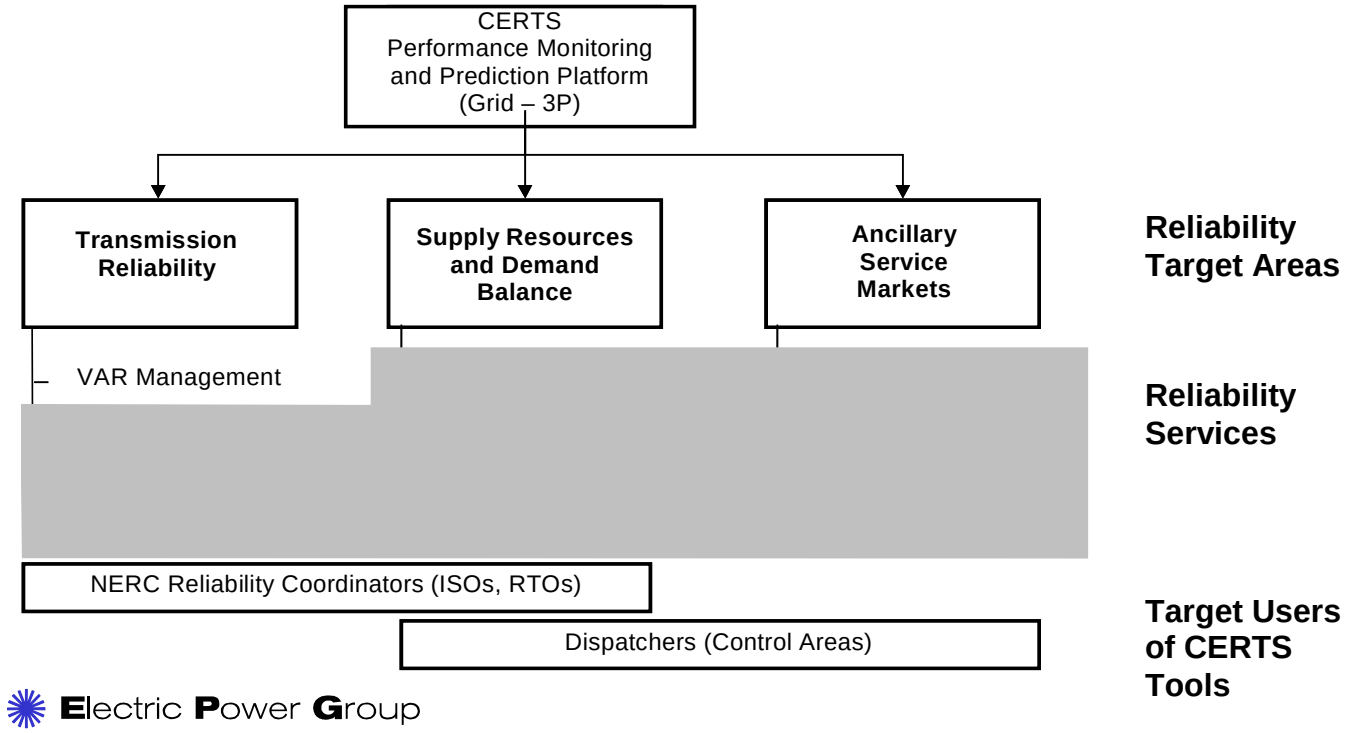
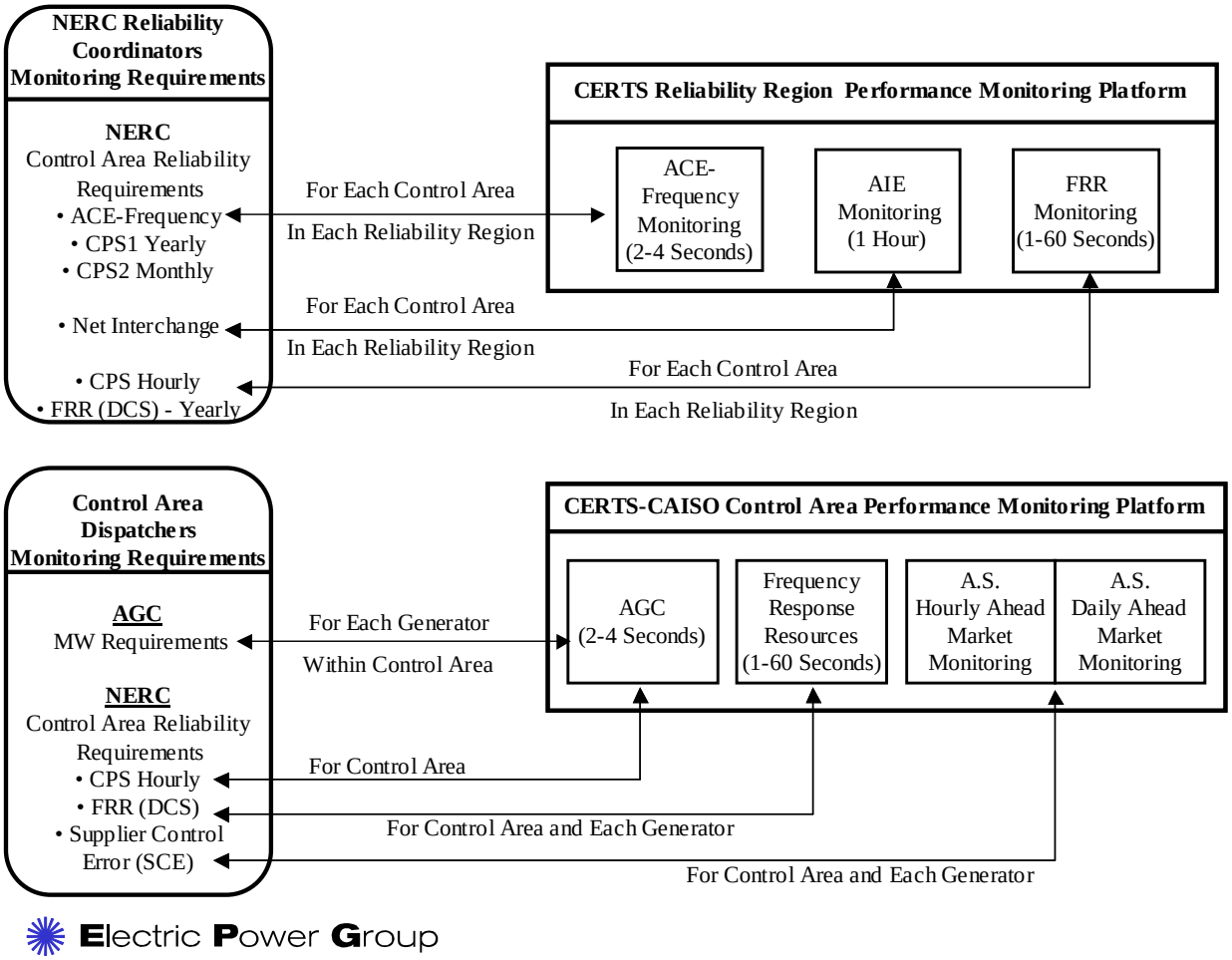


Figure 4 shows an overview of Grid-3P for real-time monitoring for NERC Reliability Coordinators and Control Area Dispatchers. The top part from Figure 4 shows the applications targeted for Reliability Coordinators: ACE-Frequency, AIE and Control Performance Standards (CPS). The applications indicated in this part have been designed, deployed and tested by NERC Reliability Coordinators. The bottom part from Figure 4 shows the applications targeted to Control Area Dispatchers: performance compliance of control areas and suppliers to AGC, FRR, and Ancillary Services markets and is being developed for CAISO. NERC Reliability Coordinators monitor several system parameters, including ACE-Frequency, to maintain and enhance the reliability of their jurisdictions. The ACE-Frequency Monitoring System, shown in the upper applications box, provides applications for each Coordinator within each of their reliability regions. Reliability Coordinators utilize those applications to monitor performance and compliance within their regions and notify the appropriate Control Area Dispatchers as abnormalities occur. Control Area Dispatchers can then pinpoint internal problems by reviewing their own performance and monitoring the performance of their service providers. In combination, this provides an integrated platform for monitoring reliability and control area performance.

Figure 4: CERTS Grid 3-P Technology Platform for Reliability and Supplier and Control Area Performance Monitoring



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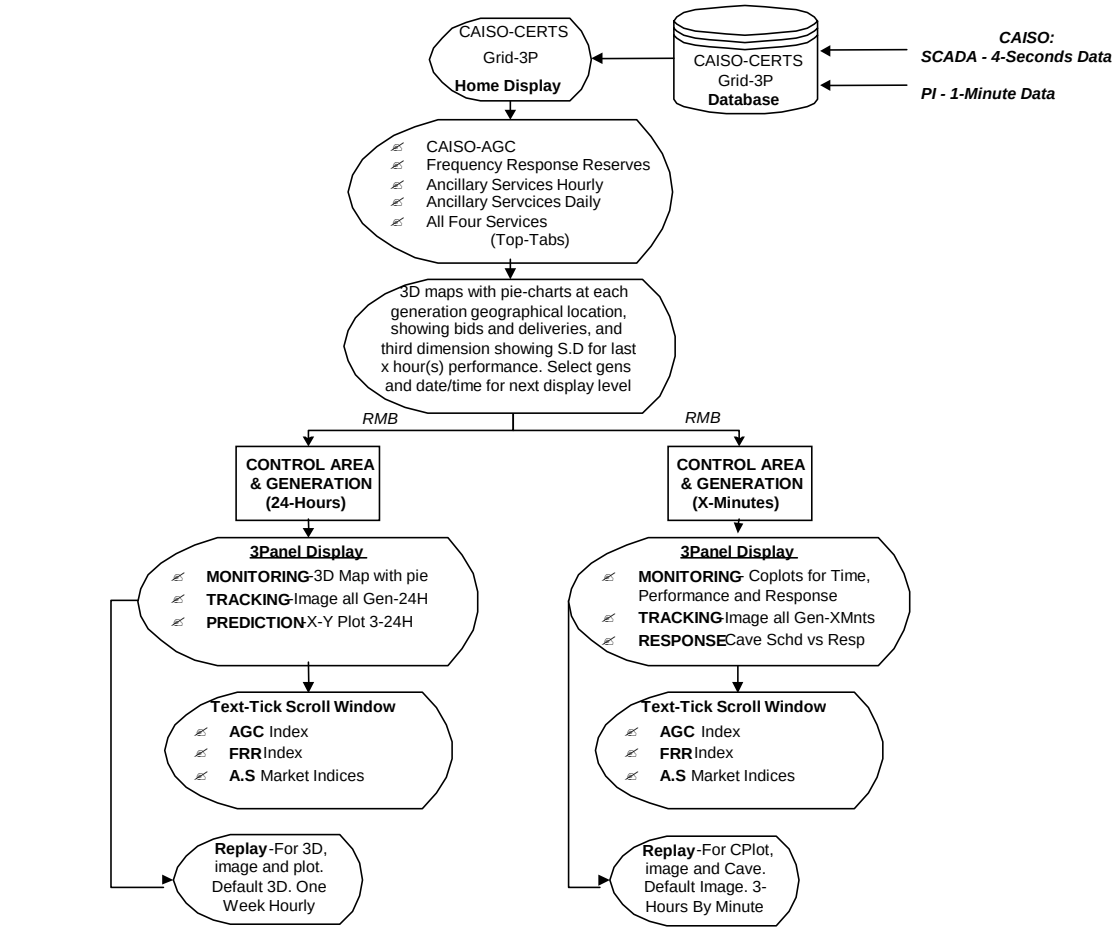
System Visualization Overview

A hierarchical approach is utilized for visualization displays. In this hierarchical approach, very critical data is presented at the high level on a very simple system display. From the high-level system display, System operators go to lower level detailed displays in the hierarchy.

As shown in Figure 5, the Supplier and Control Area Performance Monitoring System provides displays to monitor the current time, last 24-hours and last X-minutes (default 10-minutes). The application also enables monitoring of Supplier response, forecast and tracking of AGC, FRR, and hourly and daily Regulation Ancillary Services. In addition, system operators will also have an integrated window that shows performance for all four services simultaneously, and provides replay capability for displays on either of the panels from 3-panel displays.

Figure 5: Supplier and Control Area Performance Monitoring System for AGC, FRR and AS



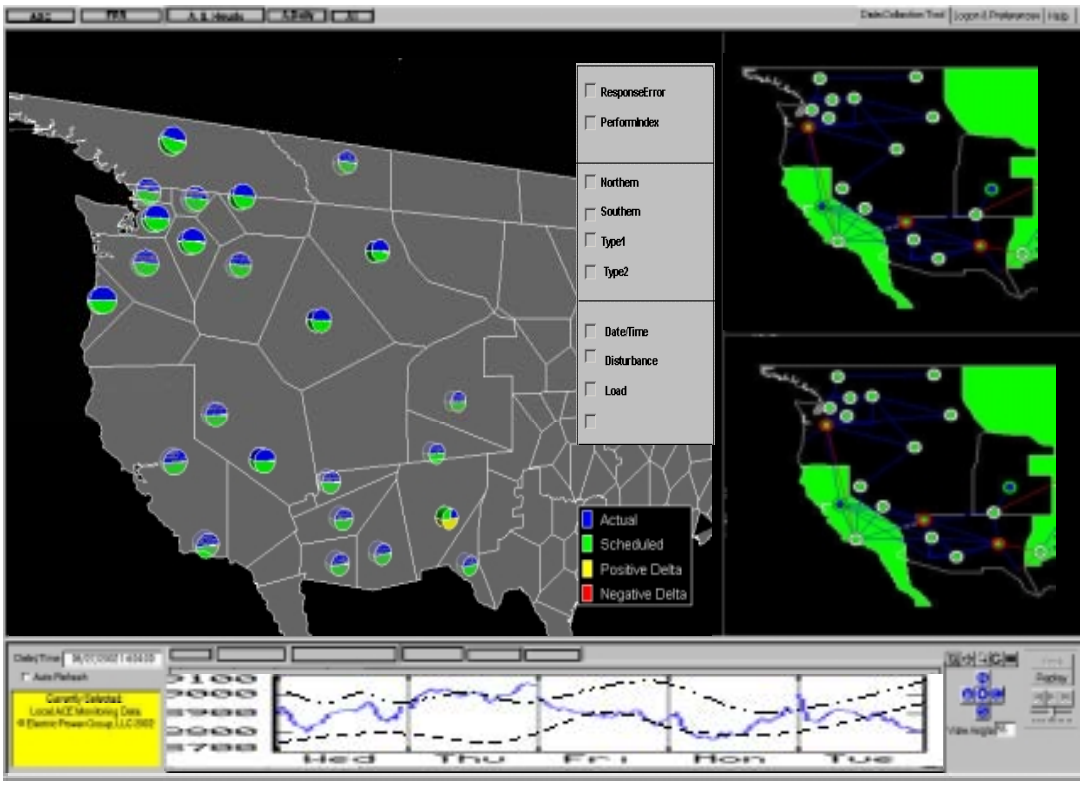
PERFORMANCE SYSTEM OVERVIEW AND ILLUSTRATIVE EXAMPLES OF THREE PANEL DISPLAYS

Three Panel Visualizations for AGC, FRR and AS

This application allows the CAISO System Operators and management to identify, via 3-panel displays, the control area and specific supplier performance for each service on geographical displays for current time, the last X minutes (default ten minutes). In addition, the past 24-hours on image-displays and user-selected supplier predictive performance are also available. The bottom of the 3-panel displays will be user selectable, to switch from tabular text window correlated with the data in the 3 panels, to optionally show to System Operators in a continuous horizontally scrollable window, the performance indices for AGC, FRR and regulation AS. The indices will replay continuously for a selectable period of time that will include the prediction period.

Figure 6 below shows five tabs at the top-left. Each of them presents a 3-panel display with the main panel, showing in a 3D map, the selected Supplier performance for the service selected and the other two panels showing the selected supplier performance for the other two services.

Figure 6: Panel View for Control Area & Supplier Performance (AGC, FRR & AS)



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The map and cylindrical pie-charts in the main panel display the 3-panel display in Figure 6 shows the current response of each supplier, selected from categorical options from a right mouse bottom menu, to the service selected from the tab. The other two panels also show the performance of the selected generators for the other two services.

The three windows at the left-bottom of the screen contain the date/time for the data being displayed, an option to hold the automatic data refresh, and a yellow window to indicate the current action taken by the user.

Panel View for Control Area & Generator Response to AGC

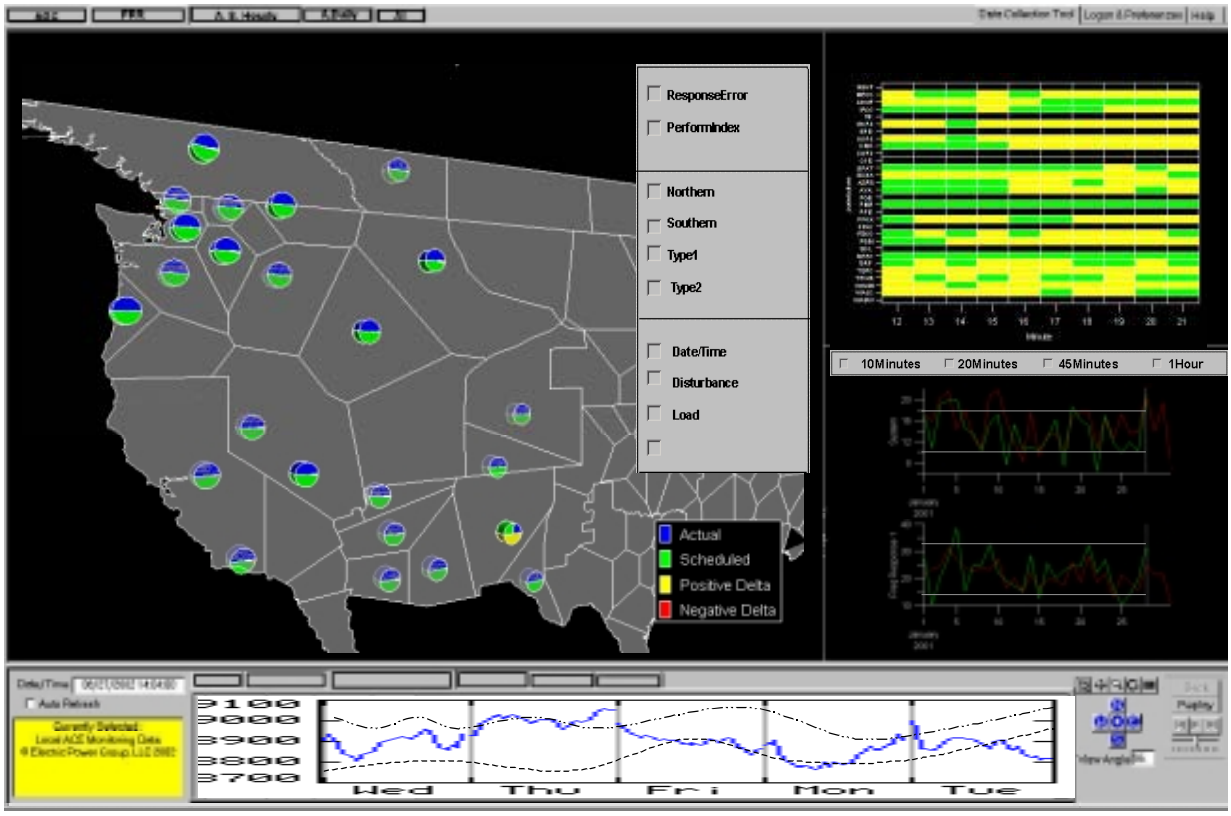
Figure 7 shows the 3D map and cylindrical pie-charts in the main panel display from the 3-panel display representing the current response of each generator, selected from menu options, to AGC, with the cylinder-height representing each generator performance index. The color-coding of the CAISO control area represents the response to AGC of all the suppliers within the control area.

The image on the top-right panel shows the performance tracking of each of the suppliers online and selected from the menu options, color-coded for the last 24-hours.

The plot on the bottom-right panel shows the predictive plot. This plot consists of a multi-series, time-based, linear chart. One series represents the recorded values of a variable over time and the second represents the predicted value for the same variable over the time period and for X additional predicted values. The plot also includes a vertical reference-line indicating the current time, relative to the time period being displayed. Multiple instances of this plot are used in the display, as illustrated, and the user selects the values for display.

The center-bottom of the 3-panel displays will be user selectable to switch from tabular text window correlated with the data in the 3 panels, to optionally show to System Operators continuously in a horizontally scrollable window the performance indices for AGC, FRR and Regulation AS. The indices will replay continuously for a selectable period of time and will include the prediction period.

Figure 7: Panel View for Control Area and Generator Response to AGC



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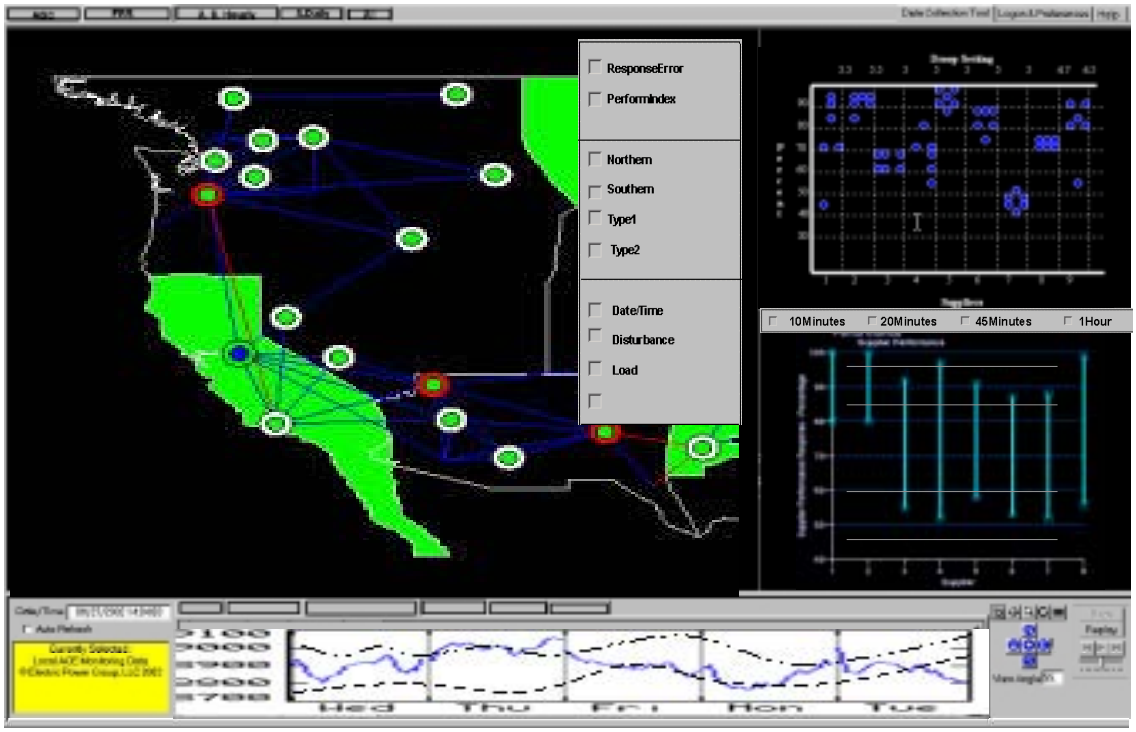
Panel View for Control Area & Generator Response to FRR

The main panel of Figure 8 shows the CAISO geographic map and two color coded concentric circles located at the geographic location of each selected generator, with the innermost circle representing the generator latest FRR response, and the outermost circle representing its expected FRR value. The height of the cylinder represents the FRR performance index for each selected generator.

The plot on the top-right panel shows the FRR performance tracking of each of the generators online, selected from the menu option, during the most recent frequency disturbances.

The plot on the bottom-right shows the current selected generators FRR performance together with its performance variance for the hour, and the value predicted for the next hour.

Figure 8: Panel View for Control Area and Generator Response to FRR



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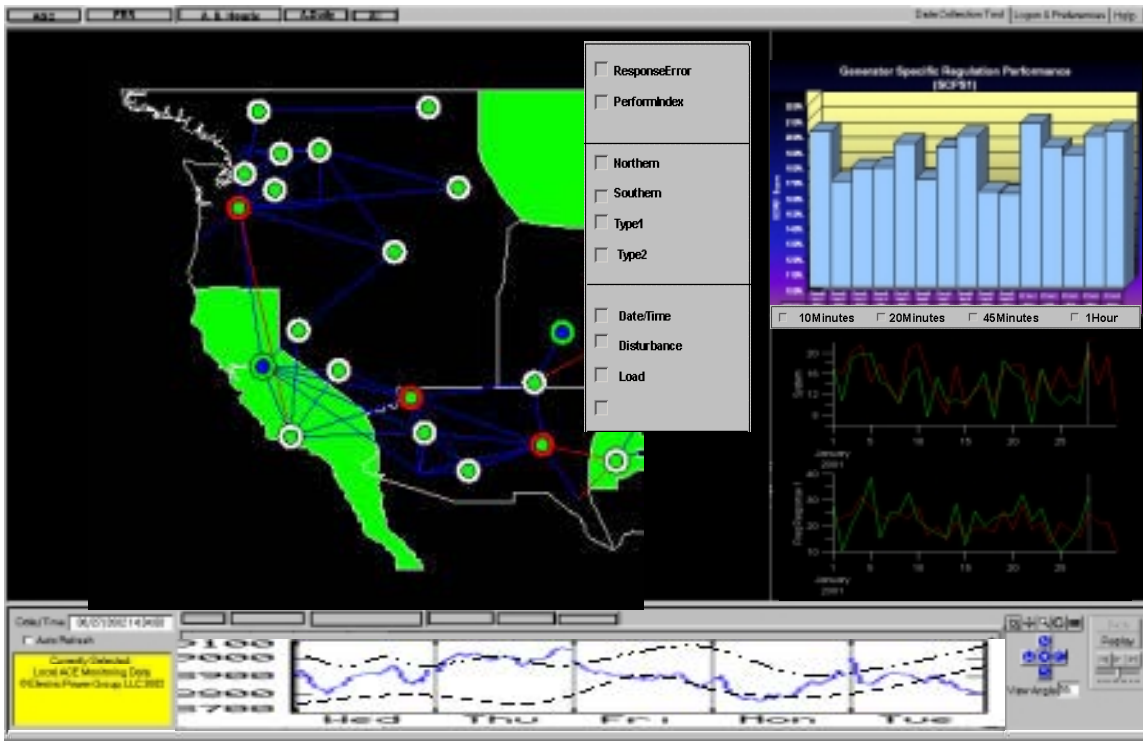
Panel View for Control Area & Generator Response to AS

The main panel of Figure 9 shows the CAISO geographic map and two concentric circles located at the geographic location of each selected generator, with the inner most circle representing the generator actual response for both the day-ahead and hour-ahead bids, and the outer most circle representing its Ancillary Service (both day-ahead and hourly-ahead) scheduled values. The height of the cylinder represents the Ancillary Services (day-ahead and hour ahead) performance indices for each selected generator.

The image on the top-right panel shows the Supplier Control Performance System for each of the generators selected, color-coded for the last X-Minutes (default 10-minutes)

The plot on the bottom-right panel shows the predictive plot. This plot consists of a multi-series, time-based, linear chart. One series represents the recorded values of a variable over time and the second represents the predicted value for the same variable over the time period and for X additional predicted values. The plot also includes a vertical reference-line indicating the current time, relative to the time period being displayed. Multiple instances of this plot are used in the display, as illustrated, and the user selects the values for display via an options dialog.

Figure 9: Panel View for Control Area and Generator Response to FRR



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SUMMARY AND CONCLUSION

The Supplier and Control Area Performance Monitoring System is designed to integrate with existing SCADA systems and provide the control area operator with near real-time monitoring, tracking and prediction capabilities of Supplier and Control Area response to AGC, FRR and AS. This application complements the existing SCADA system and will provide the user with real-time intelligence for monitoring and complying with the NERC Reliability Functional Model. The program will enhance grid operations by helping to ensure that the Suppliers provide the services they have scheduled and a means for forecasting future performance, with greater certainty.

The Supplier and Control Area Performance System is part of the suite of applications being developed for the Grid-3P platform to provide the capability to monitor grid and market performance in real time and manage grid reliability. This suite of tools include:

1. Area Control Error (ACE)–Frequency Real-Time Monitoring System
2. Area Interchange Error (AIE) Monitoring System
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4. Phasor Monitoring Applications for Dispatchers and Operating Engineers